The influence of temperature on the path-difference and on the schillerization in soda-orthoclase and moonstone.

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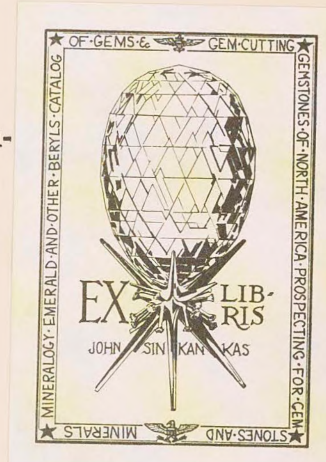
The Science Reports, Series III (Mineralogy, Petrology and Economic Geology), which have been pulished are :—



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With 3 Plates and 3 Text-figures.

As mentioned previously,[1] the schillerization of the Korean moonstone vanishes completely when the crystal is heated up to 700°C for one hour, while in the case of the Ceylon moonstone the schiller still appears but its intensity is decreased and, until the crystal begins to melt, a very faint colour is noticed.

There are two different kinds of schiller in the Ceylon moonstone, one shows a whitish pearly luster and is translucent when the mineral section is seen by transmitted light, while the schiller of the other is similar to the fluorescence colour of kerosene and the crystal appears transparent. In the former case, the colour is not much changed by heating the specimen at 700° C for one hour, while in the latter it becomes markedly fainter as the result of the same thermal treatment. In both cases, the schiller practically disappears at 1150° C which is the temperature at which the crystal begins to show a milky appearance, this indicating the commencement of fusion.

In the case of the soda-orthoclase from Frederiksvärn, the mode of change in schillerizatian on heating is somewhat different from that

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1) Kôzu and Suzuki, The influence of temperature on the optic axial angle of moonstone etc., S. R., III, Vol. 2, No 3, 197.

of the crystal mentioned above. The rate of decrease in the intensity of the colour is smaller and even in a crystal heated as high as up to 1000° C the schillerization can still be clearly noticed. The temperature at which the colour vanishes completely is one slightly lower than 1150° C, this temperature being practically the dissociation point of the crystal.

The Laue photographs taken of the basal cleavage pieces of this felspar, after they have been heated at desired temperatures, are shown in Pls. I–III. If we compare the modes of change caused by heating as shown in the Laue photographs of the soda-orthoclase and of moonstones from Korea[1] and Ceylon[2] with those of changes in the schillerization of these felspars treated thermally in the same manner, we notice that both changes are suitable for comparison. For instance, the double point system of the Korean moonstone becomes single at 700° C, at which temperature the schillerization of the crystal vanishes completely, while in the case of the soda-orthoclase the point system in still evidently double and the schillerization is not very much changed at this temperature when compared with the non-heated crystal. The double points of the soda-orthoclase can be still observed in a crystal which has been heated at 1130° C for one hour (Fig. 8, Pl. II). At this temperature the colour of this crystal is deeper than that of the Ceylon moonstone, while it suddenly vanishes completely at 1150° C, which is the temperature at which the crystal has already commenced to melt, as seen in Fig 10, Pl. III. But in the case of the slow rate of cooling of the soda-orthoclase, we can not observe in the Laue photograph any special point which corresponds to 700° C, observed in the Ceylon moonstone as mentioed before.[3]

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1) See Pls. III-VI in "X-ray analysis of adularia and moonstone", S. R.. III,Vol. I, No. I.

2) See Pl. I. in "the influence of temp. on the optic axial angle ect"., S. R., III, Vol. 2, No. 3.

3) See Figs. I-3 in PI. VII. in "X-Ray analysis etc., S. R., III, Vol. I, No. -I

Table I.

The thermal expansion of the soda-orthoclase from Frederiksvärn, measured along the direction perpendicular to the base (001),

Temperatrue in °C	Expansion in %		Temperature in °C	Expansion in %	
	Heating	Cooling		Heating	Cooling
20	0.000	0.345	600	0.410	0.535
50	0.010	—	620	0.418	—
100	0.028	—	630	—	0.560
150	0.050	0.350	650	0.445	0.570
200	0.080	0.355	670	0.460	—
210	0.090	—	700	0.505	0.585
220	0.090	—	730	—	0.605
250	0.115	0.362	750	0.580	0.610
260	0.120	—	800	0.065	0.625
300	0.155	0.380	820	0.720	—
320	0.180	—	850	0.765	0.670
350	0.197	0.400	880	0.805	—
360	0.200	—	900	0.820	0.705
400	0.240	0.430	930	0.830	—
450	0.280	0.455	950	0.840	0.745
480	0.315	—	980	0.880	—
500	0.350	0.470	1000	0.890	0.800
530	0.370	—	1020	0.898	—
550	0.370	0.495	1050	0.910	0.860
580	0.395	—	1100	0.940	0.940

The thermal expansion of the soda-orthoclase and the temperature effect on the optic axial angle of the crystal were tried to examine by the same methods as that applied to the Ceylone moonstone and the experimental results[1] of the moonston already have been published. However, owing to the impurities contained in the crystal and to its becoming translucent when the crystal plate is heated at high temperatures, the experiments in the case of the soda-orthochase were not as successful as those in the case of the moonstone. The result of the measurment[2] for the thermal expansion along the direction perpendicular to the base (001) is given in Table I and the relation between the expansion and the corresponding temperature is

1) KÔZU and SAIKI,- The thermal expansion of alkali felspars, S. R., III, Vol. 2, No. 3, PP. 203-238.

2) The measurement was made by S. Saiki in our Institute under the guidance of one of the authors, we wish to express our thanks for his help.

shown in Fig 1, in which 500° C is only a temperature fairly well distinguishable to show volume change taking place in a special rate. Other changes such as those at 700° C, 900° C etc., which were observed distinctly in other alkali felspars, are not very well determined in this felspar, this being essentially due to the impurities contained in it.

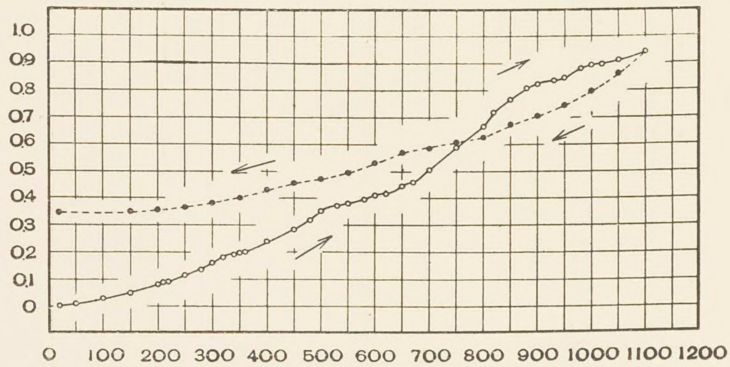

Fig. 1. The thermal expansion of soda-orthoclase from Frederiksvarn, measured along the direction perpendicular to the base.

Another method which was applied to the crystal with the object of finding the temperature at which its thermal properties change suddenly was that of the measurement of the change in the path-difference of the transmitted light through the crystal caused by heating. The measurement was made for three different thin sections parallel to (001), (010), and (100) respectively. The mineral sections were heated in an electric-resitance furnace at desired temperatures, for one hour in each case and were then quenched. The path-difference was determined by compensation method using a polarization microscope with a Seidentoph Compensator attached. The results are as given in Table II.

The figures which show the change in path-difference in the accompanying Table are not very accurate, but they are sufficiently so for determing the change qualitatively. The changes in the retardation with the temperatures given in the above Table are drawn diagrammatically in Fig. 2. From the diagram, it is evident that the change at 500° C is only observed in the curve of the section parallel to (100),

Table II.

Change in the path differeuce of the soda-orthoclase from Frederiksvärn.

Temperature at which the crystal was heated	Time for heating	Scale reading of retardation which is zero.
Section parallel to (100)		
18°C	1 hour	4.50
100	"	"
200	"	"
300	"	"
400	"	"
500	"	4.52
550	"	4.53
600	"	"
650	"	"
700	"	"
750	"	4.55
800	"	4.57
850	"	"
900	"	4.59
950	"	4.54
1000	"	4.52
1050	"	"
1100	"	4.51
1150	"	4.17
Section parallel to (010)		
18	1 hour	3.10
100	"	"
200	"	"
300	"	"
400	"	"
500	"	"
550	"	"
600	"	"
650	"	"
700	"	"
750	"	3.07
800	"	3.05
850	"	3.04
900	"	3.03
950	"	3.02
1000	"	3.01
1050	"	3.00
1100	"	"
1150	"	2.90

Table II. (*Continued.*)

Section parallel to (001)		
18	1 hour	3.93
100	"	"
200	"	"
300	"	"
400	"	"
500	"	"
550	"	"
600	"	"
650	"	"
700	"	"
750	"	3.98
800	"	3.99
850	"	4.00
900	"	4.01
950	"	4.02
1000	"	4.03
1050	"	4.02
1100	"	4.01
1150	"	3.70

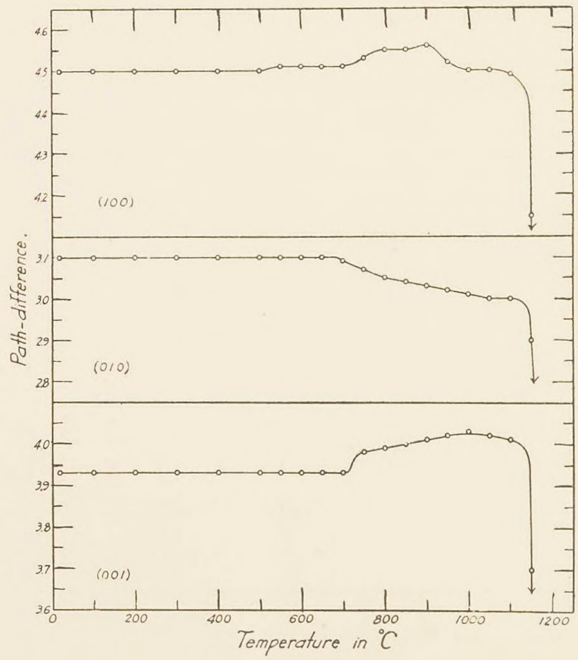

Fig. 2. Soda-orthoclase from Frederiksvärn. The curves show the change in retardation caused by heating

while the one at about 700° C is seen in all the curves obtained from the three different directions. The path-difference observed on the section parallel to (010) decreases in value at higher temperatures than 700° C, in spite of the fact that in the other two sections it increases with a rise of temperature. In the curve obtained from the section parallel to (100), the maximum value corresponds to about 900° C. which is the temperature at which the optic axial angles of the aduralia from St. Gotthard and of the Ceylon moonstone change rapidly, as already mentioned.[1] At 1150° C, the curves drop rapidly in all cases of the three different sections, this indicating the commencement of fusion.

For comparison, the same phenomena in the Ceylon moonstone were measured in parallel by the above experiments and the results are given in Table 3 and Fig. 3. The change at 500° is only observable

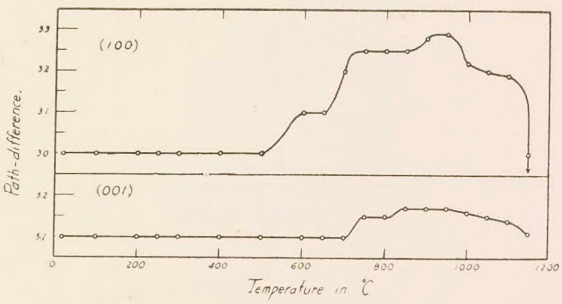

Fig. 3. Moonstone from Ceylon. The curves show the change in the retardation caused by heating.

in the curve obtained from the section parallel to the plane of schillerization which is nearly parallel to (100), the case being the same as that of the soda-orthoclase. The changes at 700° C and at 900° C or 950° C, the temperatures being characterized by rapid change in the optic axial angle and in the thermal expansion of the felspar, can also be fairly well distinguished in the case obtained by this kind of experiment, though the temperatures appear to have risen slightly higher.

1) *l. c.*

Table III.
Change in the path difference of the Ceylon moonstone.

Temperature at which the crystal was heated	Time for heating	Scale reading of retardation which is zero.
Section nearly parallel to (100).		
20°C	1 hour	3.00
100	"	"
200	"	"
250	"	"
300	"	"
400	"	"
500	"	"
600	"	3.10
650	"	"
700	"	3.20
750	"	3.25
800	"	"
850	"	"
900	"	3 28
950	"	3.29
1000	"	3.22
1050	"	3.20
1100	"	3.19
1150	"	3.00
Section parallel to (001)		
20	"	5.10
100	"	"
200	"	"
250	"	"
300	"	"
400	"	"
500	"	"
600	"	"
650	"	"
700	"	"
750	"	5.15
800	"	"
850	"	5.17
900	"	"
950	"	"
1000	"	5.16
1050	"	5.15
1100	"	5.14
1150	"	5.11

From what we have stated above, it is seen that there are three different temperetures, viz 500° C, 700° C and 900°C;[1] at which the path-difference of the transmitted light through the soda-orthoclase changes at special rates. These temperatures are the same as those obtained in the case of the Ceylon moonstone by the measurements of the optic axial angle, the thermal expansion, and by X-ray analysis.

Hence we may conclude that the changes in the internal structure of the soda-orthoclase[2] caused by heating are simillar in their essential features to those of the Ceylon moonstone,[3] the chemical formulae of these felspars being expressed as $Or_{44.9}$ $Ab_{54.5}$ $An_{1.6}$ and $Or_{73.3}$ $Ab_{24.2}$ $An_{2.5}$ respectively.

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1) An inversion point at about 900° C in the crystals of albite and orthoclase, determined by the change in the pahh-difference, has been described by Merwin, J. Wash. Acad. Sci., I. 59(1911)

2) SiO_2 =66.21, Al_2O_3 =18.89, Fe_2O_3 =0.14, CaO=0.34, Na_2O=6.75, K_2O=7.29 and total=99.62; analysed by K. Seto.

3) SiO_2 =65.87, Al_2O_3 =19.70, CaO=0.49, Na_2O=2 62, K_2O=12.06, total=100.74, analysed by K. Seto.

Fig. 1. Soda-orthoclase. non-heated.

Fig. 2. Heated at 405°C for 30 minutes, then quenched.

Fig. 3. Heated at 600°C for 30 minutes, then quenched.

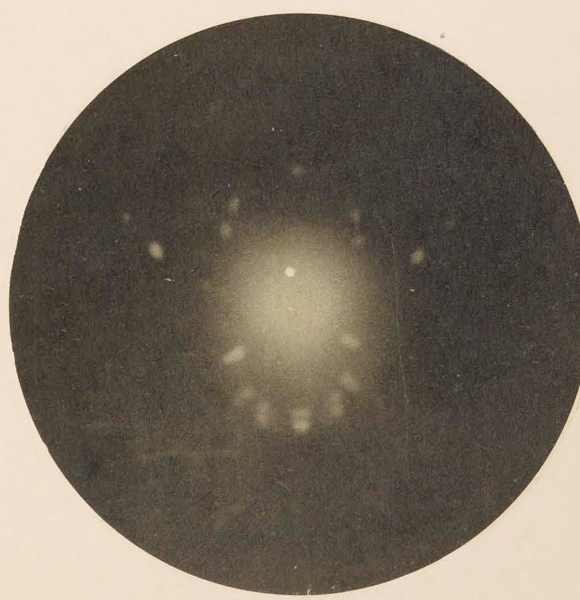

Fig. 4. Heated at 800°C for 30 minutes, then quenched.

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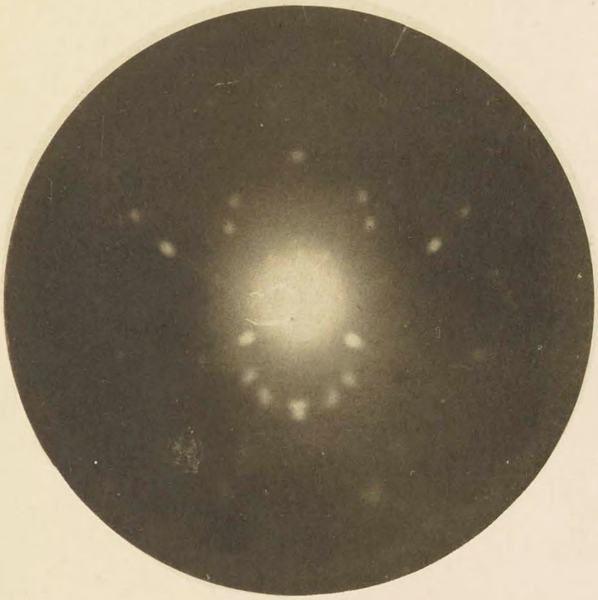

Fig. 5. Heated at 1000°C for 30 minutes, then quenched.

Fig. 6. Heated at 1030°C for 30 minutes, then quenched.

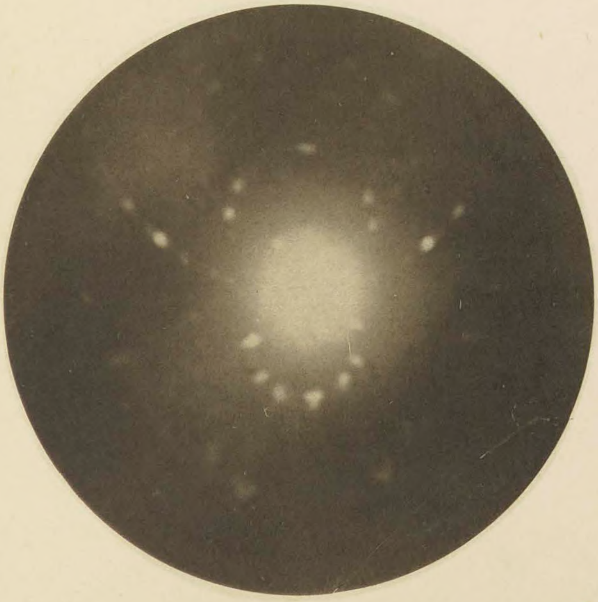

Fig. 7. Heated at 1030°C for 30 minutes, then quenched.

Fig. 8. Heated at 1130°C for 30 minutes, then quenched.

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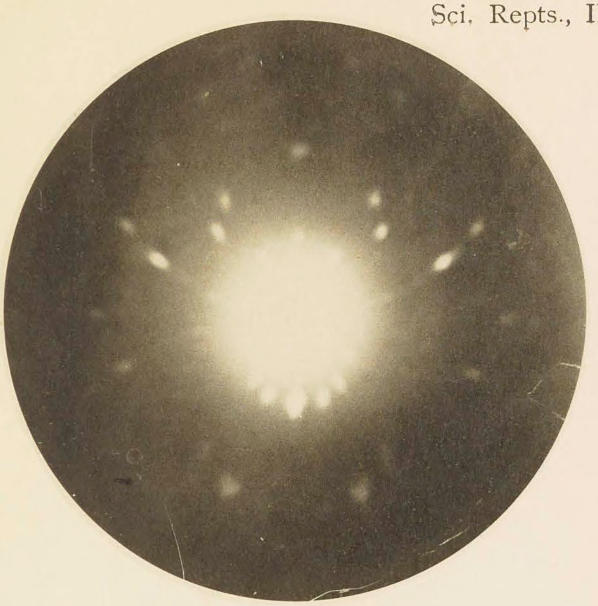

Fig. 9. Heated at 1130°C for one hour, then quenched.

Fig. 10. Heated at 1150°C for one hour, then quenched.

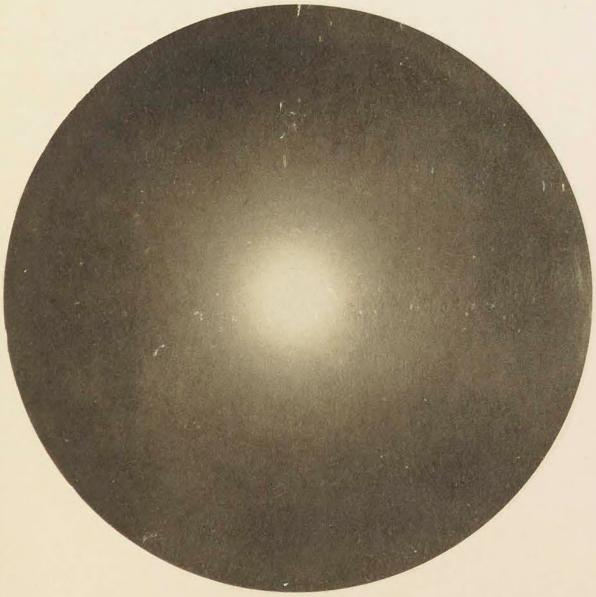

Fig. 11. Heated at 1180°C for one hour, then quenched.

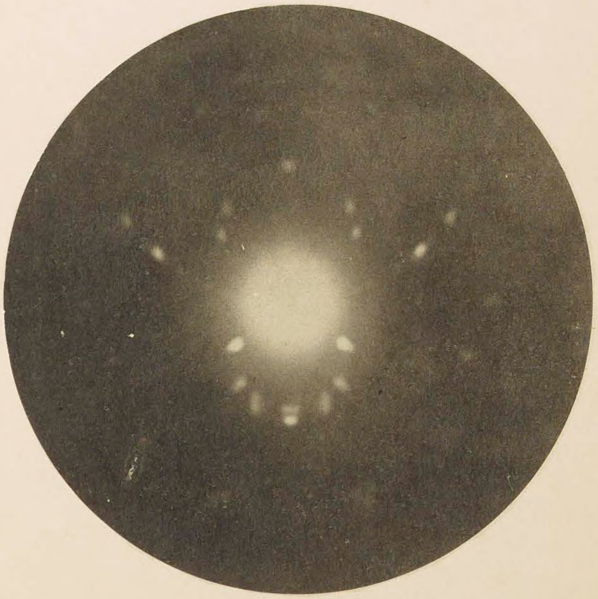

Fig. 12. Slowly cooled from 1100°C to room-temperature.